Bottom Stationed Ocean Profiler

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LONG-TERM GOAL

The long term goal is development and utilization of a bottom stationed autonomous ocean profiler. The system is capable of bi-directional satellite communcation via the ORBCOMM system, is user programmable and can store and/or transmit aquired data in near real-time. Deployment of large numbers of BSOP systems, each equipped with a highly capable sensor suit, can be used to synoptically observe marine environments with very low initial capital investment and even lower operations costs.

OBJECTIVES

The project's objective is to develop a bottom stationed ocean profiler (BSOP) capable of a minimum of 150 profiles within a 3 month time period, having satellite link near real-time communication capability. The objective includes building 4 BSOP units (one prototype and 3 copies) and adapting sensors to at least one unit for test deployments. Testing of developed units will take place in near shore and local waters.

APPROACH

The BSOP unit includes the following components: 1) instrument frame; 2) evacuation canister, tank and control system; 3) internal microcontroller with data storage; 4) CTD; 5) payload module; 6) remote communication system; 7) power supply; and 8) antifouling system. The design is based on earlier work (Davis, et al. 1992) for development of drifting system; the significant difference is the ability to hold general position by stationing on the sea floor. This has importance in the targeted application of studying large-scale phenomena using an array of simultaneously profiling BSOP units.

BSOP is designed to ascend at approximately 0.5 meters per second. CTD and payload[1] data are acquired at 2-second (1 meter) intervals and stored in internal memory. Once on the surface, the unit acquires a GPS location fix and then transmits acquired data via satellite communication link. Data transmitted consists of GPS position and data gathered from the previous descent-ascent cycle. Once data transmission is complete, the unit floods its internal buoyancy canister and descends at approximately 0.5 meters per second, gathering data along the way, until impacting the sea floor. The internal microprocessor shuts down power and enters a "sleep" mode until an internal real time clock initiates a wake-up and the cycle repeats.

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[1] Payload data spatial/temporal sampling frequency is instrument and user program dependent.

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Deployments incorporate a program to profile up to 4 times per day with a maximum deployment duration of 3 months.

The instrument frame is constructed of aluminum and includes a mounting system (couplers) for the buoyancy canister, power supply, microcontroller, payload section, and transceiver/antenna system. Weighting (drop-weight and batteries) keeps the profiler's center-of-gravity far below the buoyancy canister. This, along with the tubular construction, allows the unit to maintain a generally fixed attitude while ascending or descending as well as on the surface.

The buoyancy canister is connected to a pump (for oil evacuation) and motor-actuated valve (for flooding). The pump and valve are controlled by an adjacently mounted microcontroller system. The microcontroller is the OSIS system developed by the USF Center for Ocean Technology. The OSIS system is based on the Motorola 68HC16, has up to 64 megabytes of internal data storage memory, real-time clock and very low power sleep mode capability. The microcontroller monitors a BSOP-integrated CTD's pressure transducer and can actively adjust the profiler's buoyancy to maintain uniform ascent/descent velocity.

The power supply uses lead acid batteries configured in an isolated "multibank" arrangement, with each bank used one at a time in sequence. The microcontroller monitors the health of each bank and can "choose" to skip a bank if a weak cell or failure is detected. A lithium coin cell powers the microcontroller's real-time clock (and watchdog timer) and 2-D-sized alkaline cells power an on-board radio beacon. A drop weight system, corrodible link, and LONWorks watchdog are all available to initiate an emergency ascent if necessary. A second internal microcontroller monitors the main microcontroller's status. Failures in the system can be detected and communicated though a logically OR'd connection to an ORBCOMM transceiver. If the microcontroller detects a major system failure (buoyancy system), the drop weight is activated and the unit surfaces. If the unit at any time exceeds a depth of 150 meters it will surface. A watchdog timer within the drop weight assembly can detect a system failure independent of the main and redundant microcontrollers. In the event of total electronics failure, a corrodible link will finally release the drop weight. In all cases a radio beacon is automatically activated on the surface and the ORBCOMM transceiver is instructed to transmit position information once per hour.

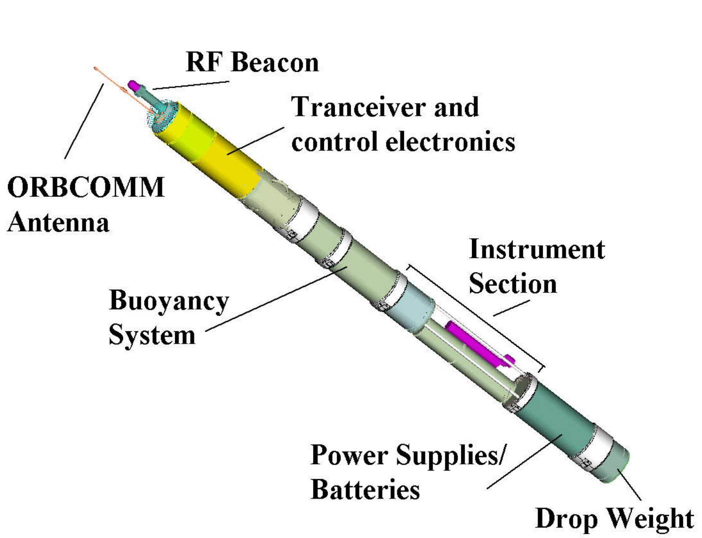
The communication system is a bi-directional satellite link using ORBCOMM. This system provides 24-hour a day, nearly global, coverage and allows rapid economical communication with the remote profiler while it is on the surface. Commands can be downloaded to the profiler to alter its cycle frequency, change its profiling rates, command the payload, etc. Communication can be set up through Internet e-mail applications or can be accessed directly though a digital telephone link to the ORBCOM ground station.

Antifouling paints and coatings and a bromine system ensures proper operation of the instrument's payloads. The buoyancy system is sufficient to overcome additional weight induced by growth load.

WORK COMPLETED

A. BSOP Platform

The main BSOP housing system is designed and 75% complete in construction. Four units are presently being fabricated for assembly and test later this year. The unit is constructed of aluminum that is anodized and powder coated for complete corrosion protection. The total length, depending on selected sensor package, is approximately 2 meters, diameter is 20 cm, and weight is approximately 150 Kg.



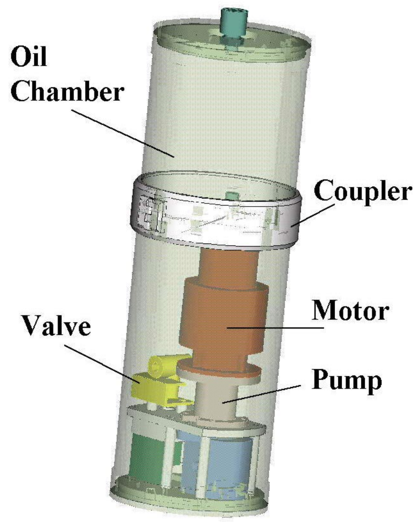
1. BSOP Mechanical Design

The satellite communication section is a flooded polycarbonate compartment. Individual antennae are potted to protect sensitive elements from the environment. Potting materials used do not significantly attenuate the ORBCOMM message transception (~140 MHz) or GPS raw signals (~1.3GHz). The RF beacon is a commercially available unit that is activated by the BSOP internal microcontroller when the system is at surface.

The BSOP power supply system, cabling, mounting methodologies, and internal communications network makes integration of sensors straightforward. Very high mass instruments (approaching 75 Kg) can be accommodated without significantly affecting ascent and decent performance. Neutral density in seawater is achieved through use of cylindrical syntactic foam situated towards the top of the BSOP unit.

B. Buoyancy system

The BSOP buoyancy system is designed and is being tested. The *ProEngineer* design is shown below in Figure 2. The slightly less than one gallon oil reservoir is actively pumped out to a neoprene bladder to provide approximately 6 lbs of positive buoyancy for the BSOP unit. (A check valve is placed in line to assure no backflow once the pump stops.) This is accomplished in approximately 30 seconds and provides sufficient buoyancy to ensure a 0.5-meter per second ascent rate. When descent is desired a motor actuated valve is held open to allow oil to return to the reservoir.

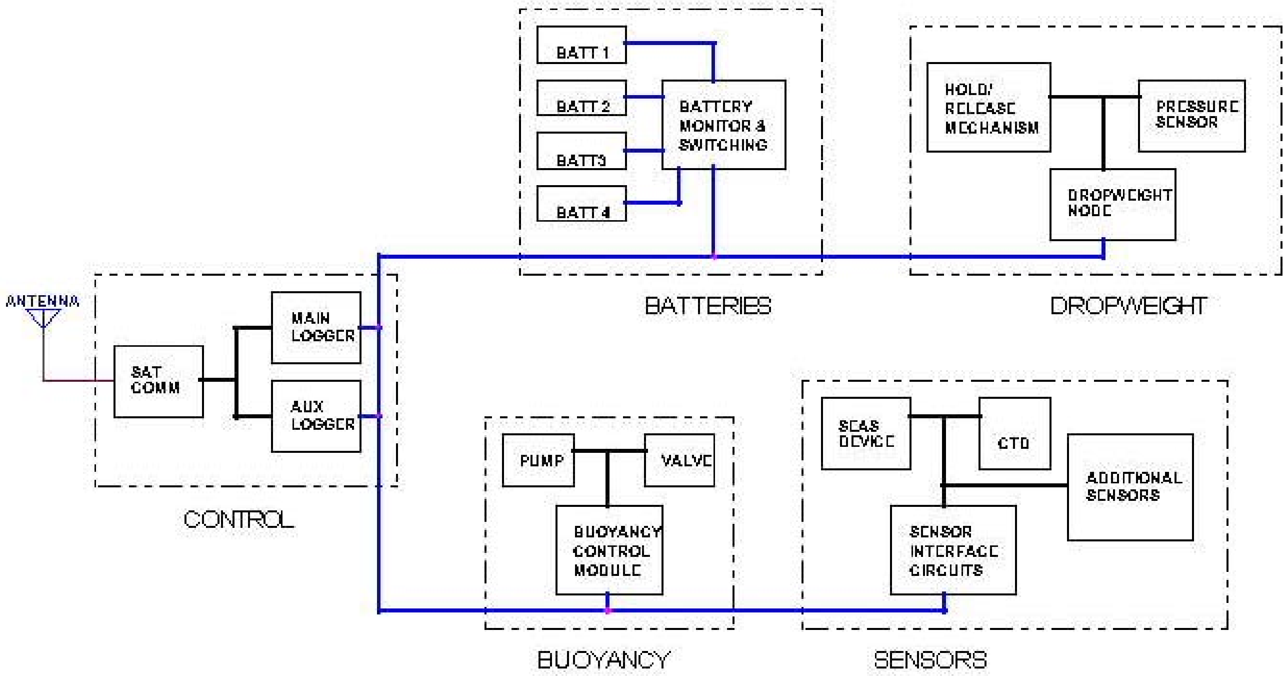


2. BSOP buoyancy system

C. Electronics

Electronics within the BSOP are based on a redundant microcontroller arrangement. The main microcontroller controls the buoyancy system, polls attached instruments, stores data, and communicates via the ORBCOMM transceiver. The redundant microcontroller monitors the status of the main microcontroller and can also communicate with the ORBCOMM transceiver.

Design of all electronics is 90% complete and several sub-component boards have been fabricated and tested. Figure 3 shows the overall control electronics system design.



3. BSOP electronics block diagram

D. Software

Software design is complete and control subroutines are being written. Integration with hardware is expected within 4 weeks. A major software challenge has been with the ORBCOMM transceivers. Documentation on the standard binary protocol is not thorough. As a result, empirical work must be completed to ensure robustness of written routines. There has been significant delay from the selected transceiver vendor that has imposed a delay on this potion of the project. Despite this delay, however, a contract has been negotiated with ORBCOMM to allow very economical data communications with the BSOP units. An alternate hardware vendor is presently being pursued.

RESULTS

- Four BSOP units under construction and nearing completion.
- ORBCOMM communication agreement in place.
- New buoyancy system designed and being tested (usable on other systems/vehicles)
- BSOP design completed which allows broad range of sensors to be hosted in a single unit.
- A new high-reliability drop weight mechanism has been designed and is presently under construction (usable on other systems/vehicles)

IMPACT/APPLICATIONS

This project represents a directed effort to build and test systems for characterization of a wide variety of marine environments. Data gathered has direct application to predictive physical, chemical and biological process models. The systems being developed and tested are targeted for deployment in open ocean environments. Experience gained in deploying and developing the BSOP units will have significant impact on defining the appropriate tools for future automated monitoring of the ocean.

TRANSITIONS

The data output of this project will be of interest to programs involved in physical process modeling and monitoring. Others involved in the optical properties of water, and those creating biological - chemical - physical process linked models will use the system and subsequently produced data. Data gathered can also be used in conjunction with AUV sensor deployments and other forms of global ocean observatories.

RELATED PROJECTS

1) Enhanced *In-Situ* Spectroscopic Analyses of Trace Seawater Solutes; 2) Construction of *In-Situ* Underwater Mass Spectrometer

REFERENCES

R.E. Davis, D.C. Webb, L.A. Regier, and J Dufour, "The Autonomous Lagrangian Circulation Explorer (ALACE)," Journal of Atmospheric and Oceanic Technology, Vol 9, No. 3, June 1992